Total kinetic energy release in spontaneous fission of ^{255,256,258}Rf*

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Spontaneous fission (sf) is a major radioactive decay mode in the region of transuranium elements. Its study provides valuable information on the stability of heaviest nuclei. Therefore understanding the sf process is decisive for the quest of the upper end of the periodic table.
Main experimental observables are the partial sf half-lives, the hindrance factors for nuclei with odd proton and/or neutron numbers, the total kinetic energy release (<TKE>) as well as the A - and Z - distribution of the sf fragments, and the neutron muliplicities.
The commonly used technique for decay studies of heaviest nuclei, i.e. implantation of the evaporation residues (ER) into a Si detector arrangement ('stop detector') after in-flight separation from the projectile beam, is not really suited for measuring <TKE> and/or mass distributions. Firstly, recombination of charge-carriers will occur due to the high ionization density of the sf fragments. Thus, there is no linear dependence between the energy and the registered pulse-height. Specific calibration procedures (see e.g. [1]) have to be applied. Secondly, the implantation depths of the ER is smaller than the range of the sf fragments. Thus, with some probability, one of them will escape the detector, depositing only part of its energy in it. So, the measured energy value will not represent the full energy release in the sf process, and consequently the peak of the energy distribution does not represent the <TKE>. One possibility to solve that problem is to register the escaping fragment in a detector box sourrounding the implantation detector [2]. Yet, it requires a correction of the energy losses of the escaping fragment in the deadlayers of the implantation detecor and the box detector, which introduces some uncertainty.
Alternatively the peak value of the energy distribution recorded in the stop detector can be used as a measure for <TKE>. This procedure requires a reference value and in addition the same mean implantation depths for the nuclei under investigation, as the energy release of the escaping fragment depends on the length of the flight-path through the detector, hence on the implantation depth [2].
As a test case we measured energy distributions for sf products of ^{255,256,258}Rf. The nuclei were produced by the reactions ^{207}Pb(^{50}Ti,2n)^{255}Rf, ^{208}Pb(^{50}Ti,2n)^{256}Rf, and ^{209}Bi(^{50}Ti,1n)^{258}Db $\overset{EC}{\rightarrow}$ ^{258}Rf; mean kinetic energies for the ERs from these reactions were equal within $\pm 2.5\%$, and therefore also, in first order, the implantation depths. The results are compared in fig. 1, where besides the measured mean values (E_{mean}) the widths of the energy distributions are given. For ^{258}Rf a <TKE> value of 197.6±1.1 MeV is reported [3]. Using it as a reference value one obtains <TKE>/E_{mean} = 1.033 and hence <TKE>(^{256}Rf) = 197.0±1.2 MeV, and <TKE>(^{255}Rf) = 198.8±1.0 MeV. This (preliminary) value is comparable for ^{256}Rf with that given in [3] (198.9±4.4 MeV), but more precise; that for ^{255}Rf is somewhat higher than the value <TKE> = 194±2 MeV [4], obtained using the method from [2]. An improvement of the results and also information on the influence of the little energy variations of the ER may be expected from modelling the distributions by, e.g. GEANT simulations.

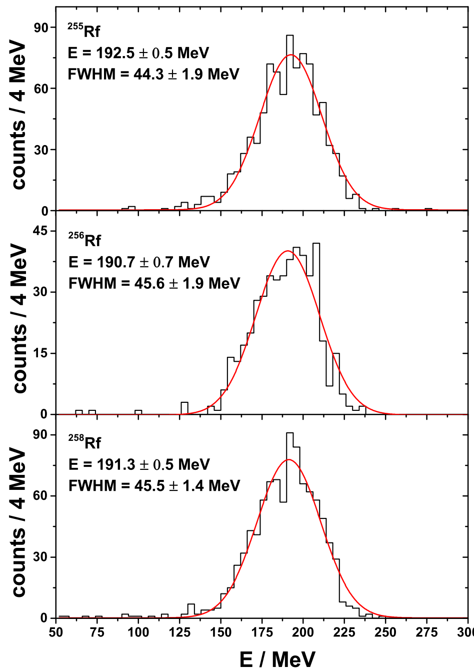

Figure 1: Energy distributions of sf events of ^{255,256,258}Rf measured with the stop detector of SHIP.

References

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